

LEAF

Comité de Pilotage

Réunion de Clôture

4 Décembre 2019

E. Dubois



Laser processing platform for functional packaging and microsystems

- LEAF identity card
- Overview of laser processing platforms
- Project progress
 - Procurement and installation
 - Access to LEAF equipments
- Human resources
- Socio-economic impact
 - Academic partnership
 - Industrial partnership
 - Collaborative projects
- Ripple effects
- Scientific production
- Sustainability



- **Second call of EQUIPEX-PIA (label Dec2011)**
- **Two partners: IEMN and LAAS**
- **Equipments: Laser processing for spot innovation**
- **S/T objectives: Packaging electronic & μ -systems**
- **Allocated funds: 1900 k€ (equipments)
700 k€ (running costs)**
- **Project duration: 91 months (7.5 years)**
 - **Tranche 1: equipment acquisition (31 Dec 2014)**
 - **Tranche 2: operational budget (31 Dec 2019)**
- **Admin management: CNRS DR18 (with DR14)**

A sound research program

- ▶ **Research program:** Integration of multifunctional systems
- ▶ **Distinctive trademarks:** - Functional Packaging (RF/mmW/THz/Opt)
- Integration of heterogeneous functional materials
- ▶ **A spot innovative platform with specialization on:**
 - **Laser photo-thermal ablation**
 μ -cutting, μ -milling, μ -drilling, μ -patterning
 - **Laser lithography & photo-induced material transformation patterning and functionalizing of multifunctional materials**



Laser processing platform for functional packaging and microsystems

- LEAF identity card
- Overview of laser processing platforms
- Project progress
 - Procurement and installation
 - Access to LEAF equipments
- Human resources
- Socio-economic impact
 - Academic partnership
 - Industrial partnership
 - Collaborative projects
- Ripple effects
- Scientific production
- Sustainability



Platform 1: Laser micromachining

Laser Processing Platform for Multifunctional Flexible Electronics

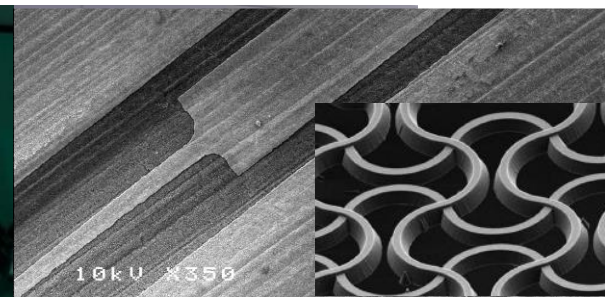
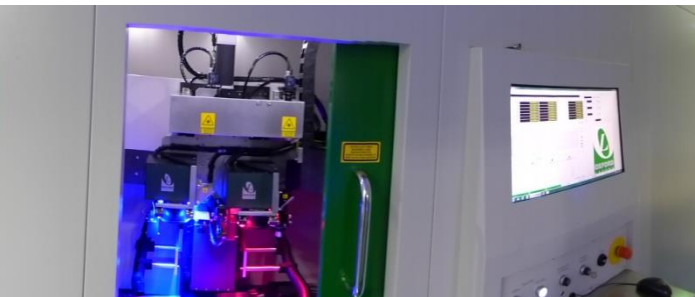
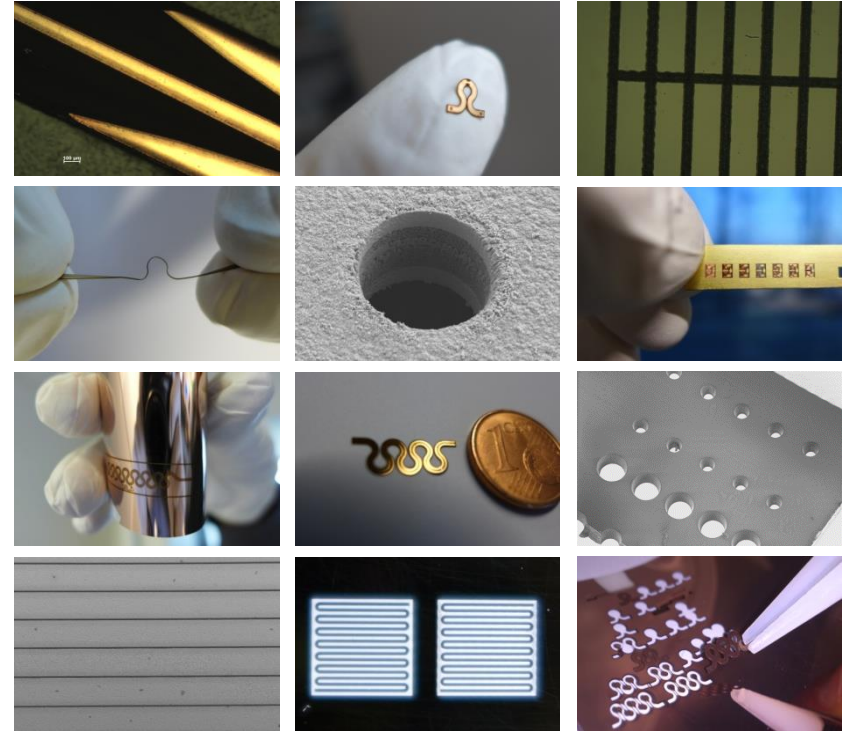
System 1

- Multi-wavelength femtosecond (300fs) diode-pumped (DPSS) lasers (343,515,1030nm)
- galvanometer deflection with extended field of 35×35mm²
- sample stage up to 300×300 mm² with linear accuracy +/- 1 μm, repeatability +/- 0.2μm
- Trepan head
- Position synchronized output (PSO)



System 2

- High power UV nanosecond DPSS laser (351nm)
- galvanometer deflection with extended field of 50×50mm²
- sample stage up to 300×300 mm² with linear accuracy +/- 1 μm, repeatability +/- 0.2μm

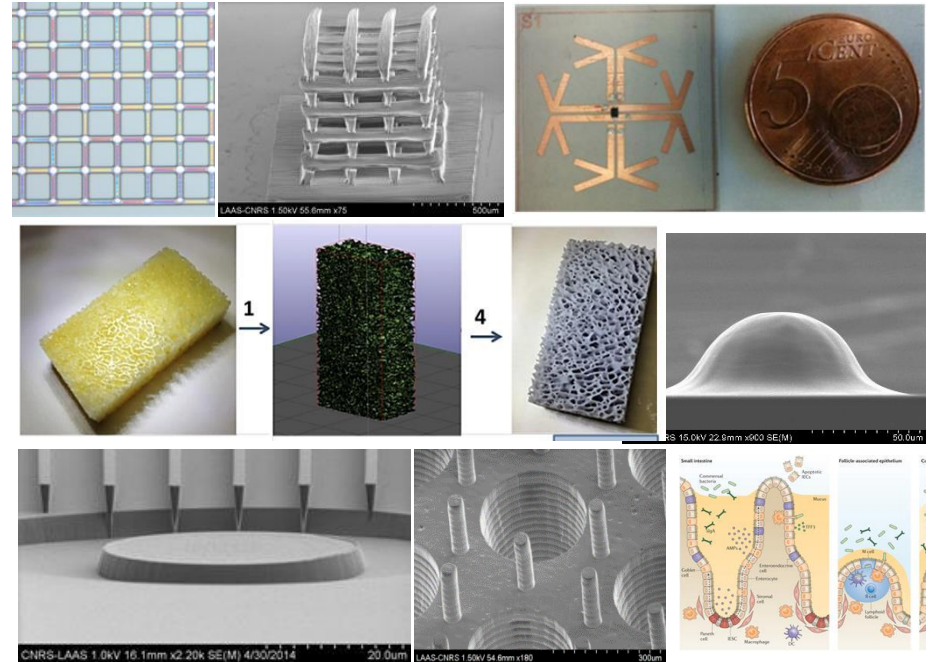


Platform 2: Laser direct writing

Laser platform for multifunctional integration

2D and 2.5 Lithography

- 3 laser lines: 375 nm, 18mW; 405 nm, 100mW; 266 nm, 100mW
- routed through 3 optical lines Ø; 1, 2, 20µm
- Alignment (video) : 400-500 nm
- Moving stage: 0.1- 20mm/s
- sample stage up to 150×150 mm²



3D Lithography

- 1 line 405 nm (50 mW)
- Resolution x,y <5µm, z - 5 to 20 µm
- Moving stage: max 150mm/s
- sample stage up to 100×100x 10 mm³

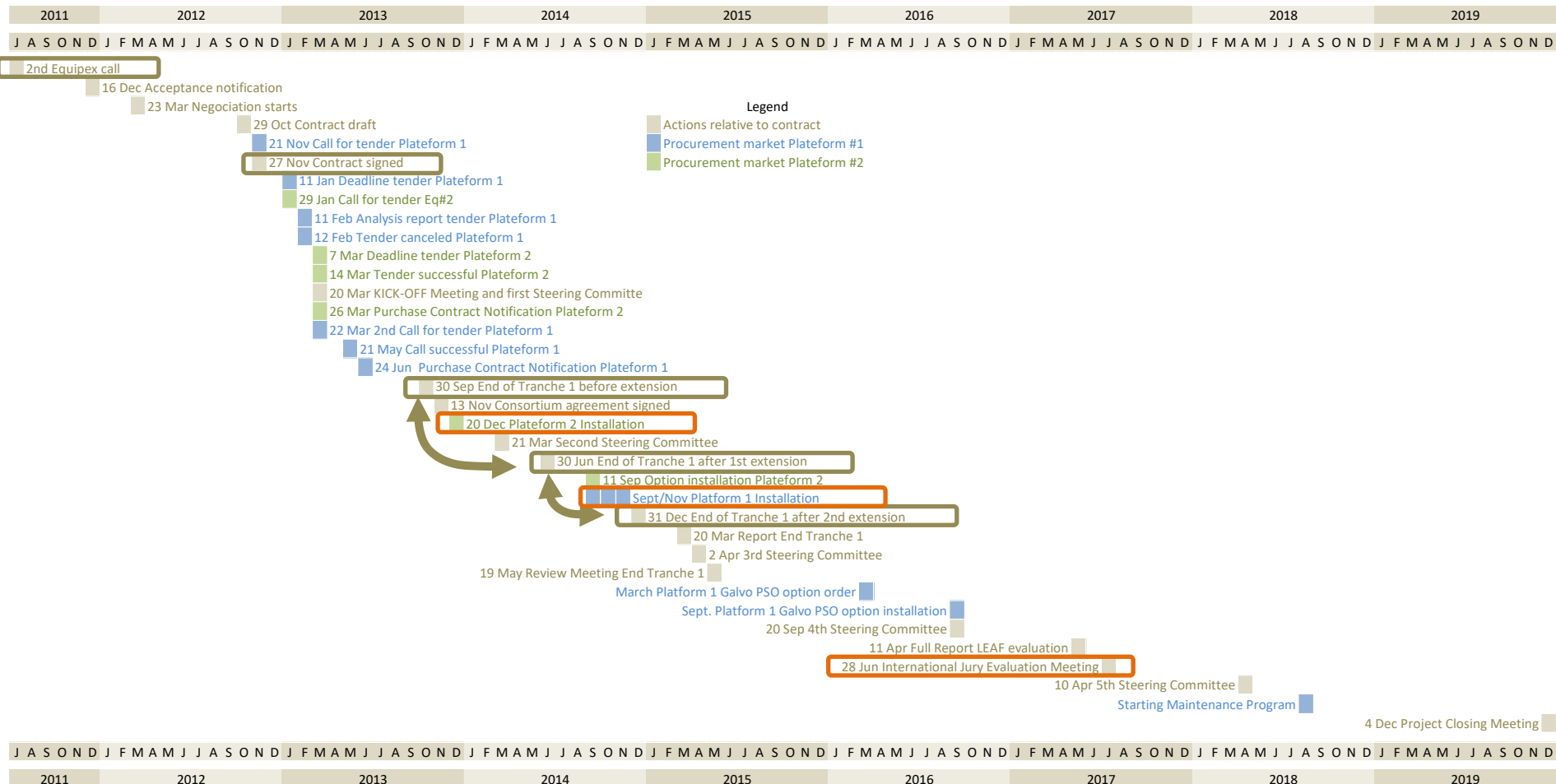


Laser processing platform for functional packaging and microsystems

- LEAF identity card
- Overview of laser processing platforms
- Project progress
 - Procurement and installation
 - Access to LEAF equipments
- Human resources
- Socio-economic impact
 - Academic partnership
 - Industrial partnership
 - Collaborative projects
- Ripple effects
- Scientific production
- Sustainability



Procurement and installation



Tranche 1: investment

Tranche 1 - Investissement	End-2014
Equipment 1: Ablation laser photo-thermique (IEMN)	1,080,000.00 €
Equipment 2: Laser 3D lithography (LAAS)	820,000.00 €
Grand Total	1,900,000.00 €

Tranche 2: running costs

2019 is currently
being processed



Dépenses IEMN										
Tranche 2 - Fonctionnement	2013	2014	2015	2016	2017	2018	2019	Total	Total Prévisionnel initial	Ecart
Equipment 1 maintenance IEMN	- €	- €	- €	- €	21,920.00 €	123,544.82 €	65,986.00 €	211,450.82 €	224,077.00 €	12,626.18 €
Missions IEMN	4,697.23 €	7,707.96 €	1,399.97 €	1,132.32 €	254.66 €	- €	- €	15,192.14 €	44,000.00 €	28,807.86 €
Consommables IEMN	1,967.40 €	16,884.68 €	22,466.58 €	17,727.42 €	9,497.23 €	15,668.89 €	- €	84,212.20 €	28,000.00 €	- 56,212.20 €
Frais de gestion 4% IEMN	266.59 €	983.71 €	954.66 €	754.39 €	1,266.88 €	5,568.55 €	2,639.44 €	12,434.21 €	11,843.00 €	- 591.21 €
Sans frais 4% gestion	6,664.63 €	24,592.64 €	23,866.55 €	18,859.74 €	31,671.89 €	139,213.71 €	65,986.00 €	310,855.16 €	296,077.00 €	- 14,778.16 €
Total IEMN DR18	6,931.22 €	25,576.35 €	24,821.21 €	19,614.13 €	32,938.77 €	144,782.26 €	68,625.44 €	323,289.37 €	307,920.00 €	- 15,369.37 €
Dépenses LAAS										
Tranche 2 - Fonctionnement	2013	2014	2015	2016	2017	2018	2019	Total	Total Prévisionnel initial	Ecart
Equipment 2 maintenance LAAS	- €	- €	15,000.00 €	34,280.00 €	46,745.96 €	- €	91,974.04 €	188,000.00 €	188,000.00 €	0.00 €
Missions LAAS	7,450.42 €	2,458.21 €	10,159.07 €	6,030.74 €	4,063.39 €	2,467.44 €	13,370.73 €	46,000.00 €	46,000.00 €	0.00 €
Consommables LAAS	18,628.60 €	3,292.40 €	26,801.14 €	14,611.86 €	29,098.01 €	28,655.48 €	21,912.51 €	143,000.00 €	143,000.00 €	0.00 €
Frais de gestion 4% LAAS	1,043.16 €	230.02 €	2,078.41 €	2,196.90 €	3,196.29 €	1,244.92 €	5,090.29 €	15,080.00 €	15,080.00 €	0.00 €
Sans frais de gestion 4% LAAS	26,079.02 €	5,750.61 €	51,960.21 €	54,922.60 €	79,907.36 €	31,122.92 €	127,257.28 €	377,000.00 €	377,000.00 €	0.00 €
Total LAAS DR14	27,122.18 €	5,980.63 €	54,038.62 €	57,119.50 €	83,103.65 €	32,367.84 €	132,347.57 €	392,080.00 €	392,080.00 €	0.00 €
Grand Total	34,053.40 €	31,556.98 €	78,859.83 €	76,733.63 €	116,042.42 €	177,150.10 €	200,973.01 €	715,369.37 €	700,000.00 €	- 15,369.37 €

Reporting to ANR, CNRS, DRRT, MEEF

Steering Committee ANR Report International Rev.	Yearly Yearly June 2017	S/T Financial
DRRT	Yearly	S/T Financial
CNRS-DR18	31 Oct 2013 7 Dec 2016	S/T Financial
MEEF	6 Nov 2014	Financial S/T
ANR	End of Tranche 1 meeting 20 Mar 2015	S/T Financial

*Mission d'Expertise Economique et Financière (MEEF) de la Direction régionale des Finances publiques

- ▶ Open access through the RENATECH network
- ▶ Shared resources and running costs

7300 m²
of clean rooms

140
clean room
engineers
and technicians

130 M€
of EQUIPEMENT

5 FACILITIES



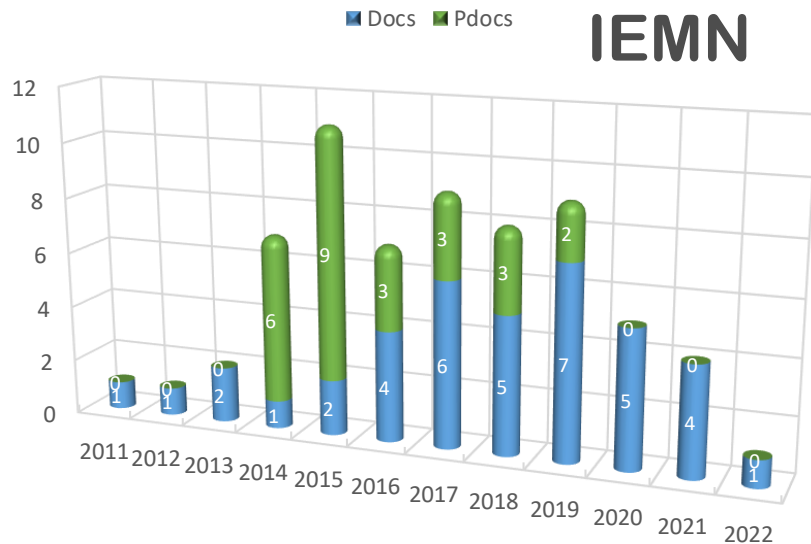
Laser processing platform for functional packaging and microsystems

- LEAF identity card
- Overview of laser processing platforms
- Project progress
 - Procurement and installation
 - Access to LEAF equipments
- Human resources
- Socio-economic impact
 - Academic partnership
 - Industrial partnership
 - Collaborative projects
- Ripple effects
- Scientific production
- Sustainability

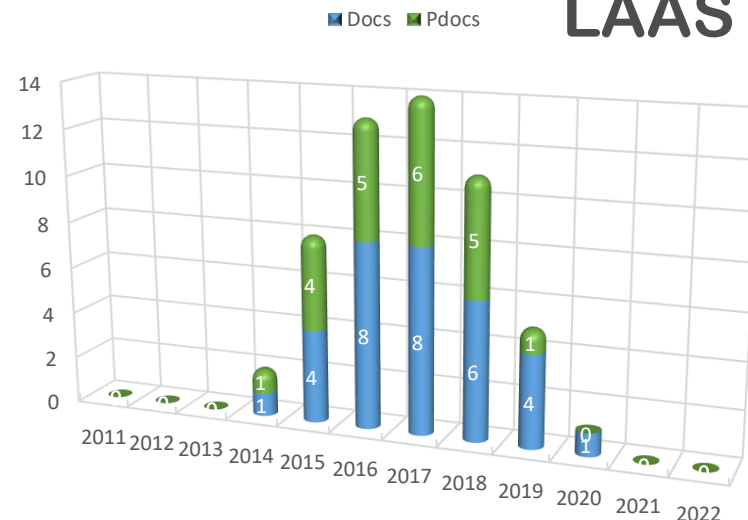


- Management Tranche 1: 31PM + 20PM permanent staff
- S&T start-up period: 5 Post-Docs funded by Regional Council (FEDER)
- S&T consolidation: - 25 PhD and Pdocs use LEAF at IEMN
- 16 PhD and Pdocs use LEAF at LAAS
- 1 CNRS permanent Engineer position assigned on LEAF platform at LAAS since 2013
- 1 CNRS permanent Engineer position assigned in Dec 2016 on LEAF platform at IEMN

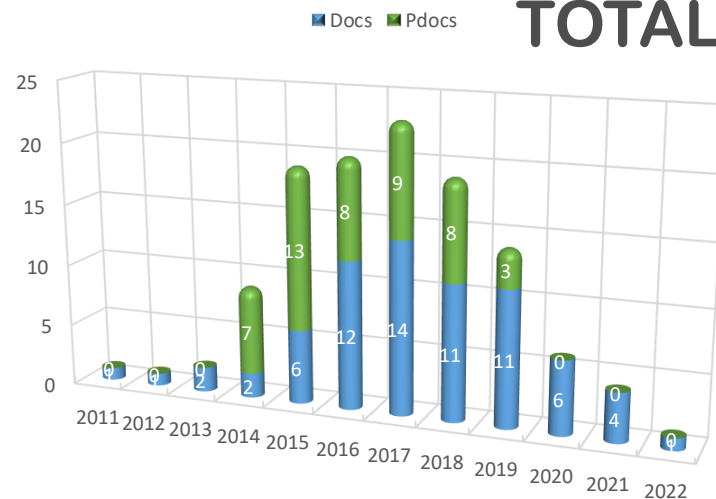
IEMN



LAAS



TOTAL



Laser processing platform for functional packaging and microsystems

- LEAF identity card
- Overview of laser processing platforms
- Project progress
 - Procurement and installation
 - Access to LEAF equipments
- Human resources
- Socio-economic impact
 - Academic partnership
 - Industrial partnership
 - Collaborative projects
- Ripple effects
- Scientific production
- Sustainability



- ~ 60 Collaborative projects are routine users
- ~ 12 Projects are 'LEAF-centric'
- 2016/2017/2018: endogenous/ exogenous technological steps
 - 400/200 techno operations (IEMN)
 - 3000H/238H time beam use (LAAS)



- ST-IEMN Common Lab: Functional packaging for RF/mmW/THz/Photonics systems



- Essilor-LAAS Joint lab: OPERA, pixelated lenses



- Contrat de plan Etat-Région-FEDER
Campus Intelligence Ambiante (CIA)
Support to EQUIPEX projects



- MC2 Microwave Characterization Center

~60

- ANR FlexiGaN: Technologies GaN mécaniquement flexible, 2013-201
- Labex GANEX: 'Réseau National des Technologies GaN', 2012-2019
- Fondation d'entreprise EADS: Artificial muscles based on electro-active polymers, IEMN, 2012-2015
- ANR ASTRID Clear Flight, Controlled lift for the efficient flight of an artificial insect, 2014-2017
- ANR GRACY: Electronique Graphène pour les amplificateurs faible bruit, 2012-2017
- FET Flagship Graphene: WP8 - Flexible Electronics, 2013-2018
- UPTeG ERC Starting Grant JF Robillard: Unconventional Principles of ThermoElectric Generation 2013-2019
- ANR ASTRID CAMELOTT: Sensors and actuators for the reactive control of micro-drone take-off, 2014-2017
- PIAVE project AUTONOTEX: Flexible electronics for connected clothes, 2016-2019
- Chaire d'Excellence THOTroV R. Peretti Régionale HdF, TeraHertz Optical Trapping of Viruses, 2018-2020
- NANO2017: Fs laser trepanning for improved RF and mmW performance, Si Photonics Optical Glass Interposer, 2014-2018
- NANO2022: Packaging fonctionnel en régime sub-mmW
- MALDI: Texturation de surface pour la spectrométrie MALDI (Matrix Assisted Laser Desorption Ionisation)
- ANR MICROTIP: Transducteurs à base de réseaux Interpénétrés de Polymères, 2015-2018
- ANR OPERA: Nouveaux matériaux absorbeurs pour cellules solaires, 2017-2020
- MicroServ: Fabrication de sondes MEMS Terahertz
- ANR Economics: Eco-Efficient and safe antifouling surfaces for milk and egg processing industries, 2018-2021
- FUI VEGaN: Développement de composants nitrure de gallium, 2016-2018
- EDA EuGaNIC: Industrial supply chain for Gallium-Nitride, 2016-2019
- ANR OLYMPIA: NNEMS probes for high speed AFM, 2015-2018
- ERC NANOBUBBLES: Laser-induced vapour nanobubbles for intracellular delivery of nanomaterials, 2015-2020
- ANR COMPACT: Compréhension et optimisation des phénomènes de pièges en technologie de puissance GaN, 2017-2019
- ANR SchoGaN: Diodes Schottky GaN pour la génération de signaux THz, 2017-2020
- ANR CAMUS: Microcapteurs de gaz ultrasensibles à transduction micro-onde et matériaux carbonés, 2014-2017
- H2020 MMAMA: Microwave Microscopy for Advanced and Efficient Materials Analysis and Production, 2017-2020
- SATT TERAPOMPE: Laser térahertz pompé optiquement par laser à cascade quantique
- SATT SSD: Diode SSD optimisée pour des applications telecoms.
- ANR BISCIG: Caractérisation totalement intégrée en bande G, 2014-2017
- ANR HEROES: Heterodyne Receivers Optimized for Synchrotron sources, 2017-2020
- ANR TERAPACIODE: Demonstrator of polymer passive circuits for THz domain, 2017-2019
- ECSEL-RIA TARANTO: Towards Advanced Bicomos nanotechnology platforms for RF and THz applications, 2016-2019

~60

- ANR ED-GaN: Co-intégration des transistors GaN à enrichissement et à déplétion, 2016-2019
- ANR BISCIG: Caractérisation totalement intégrée en bande G, 2014-2017
- Interreg V TERAFOOD: Compact and low-cost Terahertz sensor for monitoring of food quality, 2017-2020
- ANR TERASONIC: Transmissions TERAhertz combinant électronique état SOLide et photoNIQue, 2017-2020
- ANR GRACY: Electronique graphene pour amplificateur faible bruit, 2013-2016
- ANR COM'TONIQ: Communications quasi-optiques ultra-haut débit à base de photonique, 2014-2017
- SATT REFLEX2: Dispositif portatif mesurant rapidement l'activité enzymatique d'une solution
- ANR GENESE: Gestion de la lumière pour la future génération de cellules solaires, 2014-2017
- ANR ASTRID HYPOCAMP, Hybrid VECSELs controlled by polarization for optical and RF systems 2014 - 2017
- ANR Health Challenge NODENS New 3D objects for in-vivo blood analysis, 2015-2018
- PIA Nanobiotechnologies DIGIDIAG Lab on chip for Digital diagnosis, 2012-2018
- INCA HF-LYMPHO-MONITORING, High frequency analysis of B lymphoma cells under to chemical stress', 2015-2017
- ANR MovetoDiam: Diamond Vertical Power MOSFET, 2017-2021
- ANR Moly : MOlecular endoscopY for remote in vivo diagnosis 2015 – 2018
- ANR Labcom BIOSOFT : Procédès Souples Pour la Bio-détection, 2013 - 2016
- ANR DOCT-VCSEL : Tomographie par Cohérence Optique portable à source accordable MEMS-VCSEL pour l'analyse de la peau, 2016 – 2020
- ANR MIDAS : Diodes laser multiplexées en longueur d'onde pour la spectroscopie moyen infrarouge, 2015 - 2018
- ANR CALITREC : Cavité externe simplifiée pour émetteurs MIR, 2014 - 2017
- ANR MIMICSEL : VCSEL antimoniure métamorphique à cascade quantique interbande pour le moyen infrarouge, 2016 - 2020
- ANR Adiposphere: modèle 3D d'adipocytes beiges dérivés de cellules iPS humaines pour le criblage de molécules et pour la thérapie cellulaire de l'obésité, 2018 - 2021
- Projet Région Occitanie-FEDER Multifab 2017-2020
- PIA Nanobiotechnologies DIGIDIAG : Diagnostic Digital 2010 - 2016
- Région Occitanie Flowskin : New ex vivo perfusable vascularized human skin model for drug testing, 2018 - 2020
- Région Occitanie Gene Extractor: Technologie de préparation et de purification de fragments ciblés dans un mélange génomique complexe, 2014 - 2017
- SATT Prématuration TTT µLAS : 2019 - 2020
- Pilot Line HOLIFAB: Holistic digital-to-physical prototyping and production pilot for microfluidic MEMS, 2017 - 2020

Past

- CRHEA (ANR FlexiGaN, transistors sur substrat flexible)
- ONERA (ANR Clear Flight, Structuration de polymères électro-actifs)
- ONERA (ANR CAMELOTT Flight, Structuration de polymères électro-actifs)
- ENSIAME (ANR Clear Flight, Structuration de polymères électro-actifs)
- IMS (ANR GRACY, transistors graphène)
- LabSTICC (Structuration de polymère pour application mmW)
- IPGG (laboratoires sur puce)

> 30

Active

- CEZAMAT (Ingénierie substrat – suspension membrane)
- CIRIMAT (développement de résines inorganiques)
- IS2M (développement de nouveaux photopolymères)
- LAAS (perçage de verre pour réacteurs microfluidiques)
- CETHIL (ANR TIPTOP échantillon de calibration en microscopie thermique)
- Institut Néel (ANR TIPTOP échantillon de calibration en microscopie thermique)
- LABEX GANEX (Technologies GaN)
- CEA LETI, Associé EQPX LEAF
- C2N (Singulation de puces et découpe de substrats)
- Univ. Bordeaux ,GREMAN, CRHEA (MEMS résonnants pour détection biochimique)
- CRCT (Développement de tumeurs sur puces)
- CNRGV, LRP (manipulation d'acides nucléiques)
- LSPM, GEMaC, AMPERE (composants su diamant)
- LBC-ESPCI ,IPGG (système de diagnostic sur puces)
- IPBS (migrations de cellules en géométrie confinée)
- Géosciences Environnement Toulouse (Actionneurs microfluidiques laminés)
- Ecole Centrale PAris, Institut Fresnel (Diodes laser à cristal photonique)
- FEMTO-ST ,CHUB (analyse de la peau)
- IPBS, ITAV, UAB (biocapteurs biologiques hyperfréquences)
- Univ. of Barcelone, Univ. of Exeter (Intégration objets communicants sur substrat souple)
- CRCT (laboratoire sur puce)
- IS2M (MOEMS Vcsel)
- CEA (Etanchéité fondamentale)
- CEMES (composants nano)
- L2C (masques nanofluidiques)
- IMS (micro résonateurs + ondes acoustiques)

Past

COBHAM: micro-usinage de substrat de nitrure d'aluminium
 POLY-INK (Micro-usinage d'encre polymères biosourcées)
 INSTENT (Micro-usinage de puces Si sur stent)
 NIT New Imaging Technologies (Micro-usinage de capteurs d'image IR)
 THALES Global Service (Micro-usinage de boîtiers anti-intrusion)
 SOITEC (dispositif sur membrane SOI suspendue)
 3M (ANR FlexiGaN transistors sur substrat flexible)
 NEXDOT (Structuration de couches diélectriques pour imageur)
 Siltronic (Structuration de substrats silicium épais)

> 25

Active

STMicroelectronics (Laboratoire Commun IEMN-STMicroelectronics)
 ESSILOR (Laboratoire Commun OPERA)
 CEA LETI, Associé EQPX LEAF
 VMicro (projet MicroServ, fabrication de sonde MEMS THz)
 Zymoptiq (projet Reflex, mesure d'activité enzymatique)
 MC2-Technologies (fabrication de micro-PCB pour applications en ondes millimétriques)
 OXFORD-LASERS (Interface commande CNC laser)
 OMMIC (singulation de puces microélectroniques)
 Concept Scientific Instrument (ANR TIPTOP échantillon de calibration en microscopie thermique)
 PICOMETRICS (Réalisation de puces microfluidiques pour la séparation d'ADN)
 KLOE (Développements de procédés de structuration 3D)
 Innopsys (cellules en 3D, génération de motifs biomoléculaires microniques)
 Smartcatch (NODENS)
 3DIS tech (Assemblage et interconnexion 3D de systèmes électroniques)
 IBS (composants su diamant)
 MIRsense (Diodes laser à cristal photonique)
 Autoliv , Lacroix (Micro pyro systèmes)
 Exagan (composants de puissance GaN)
 Horiba (masques hautes résolutions pour la lithographie aux rayons X)

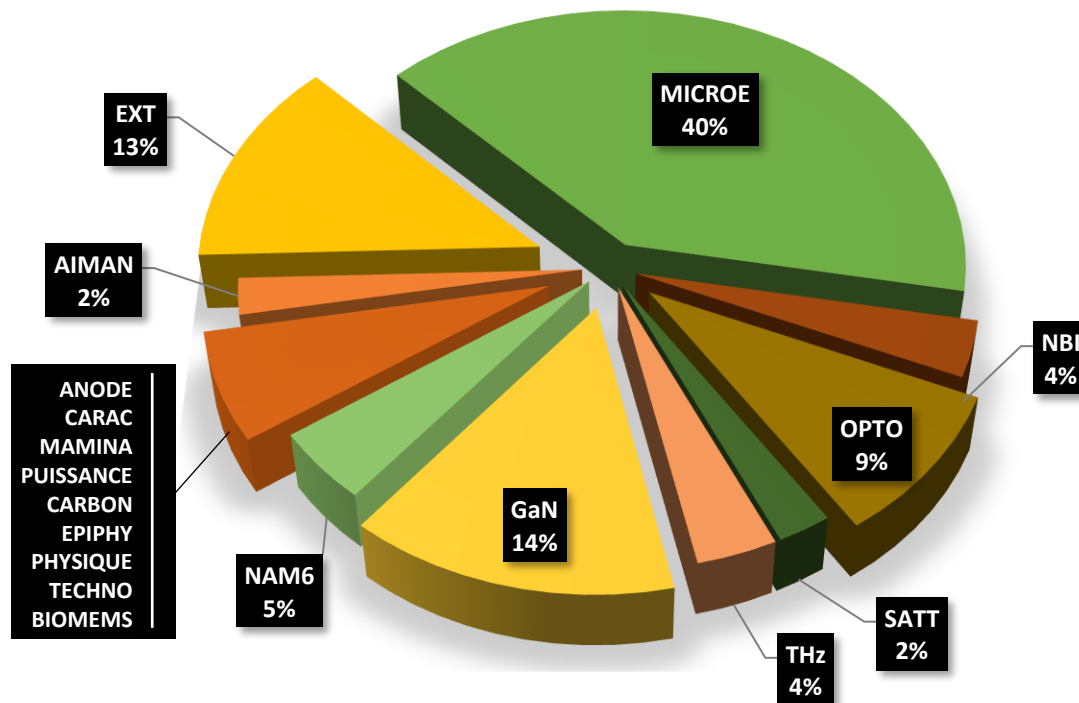
• Status of technical activity

# Tech Ope	2015/2016	2017	2018
Endogenous	141	125	130
Exogenous	70	65	63

> 400

> 200

Average yearly statistics over 2015-2019



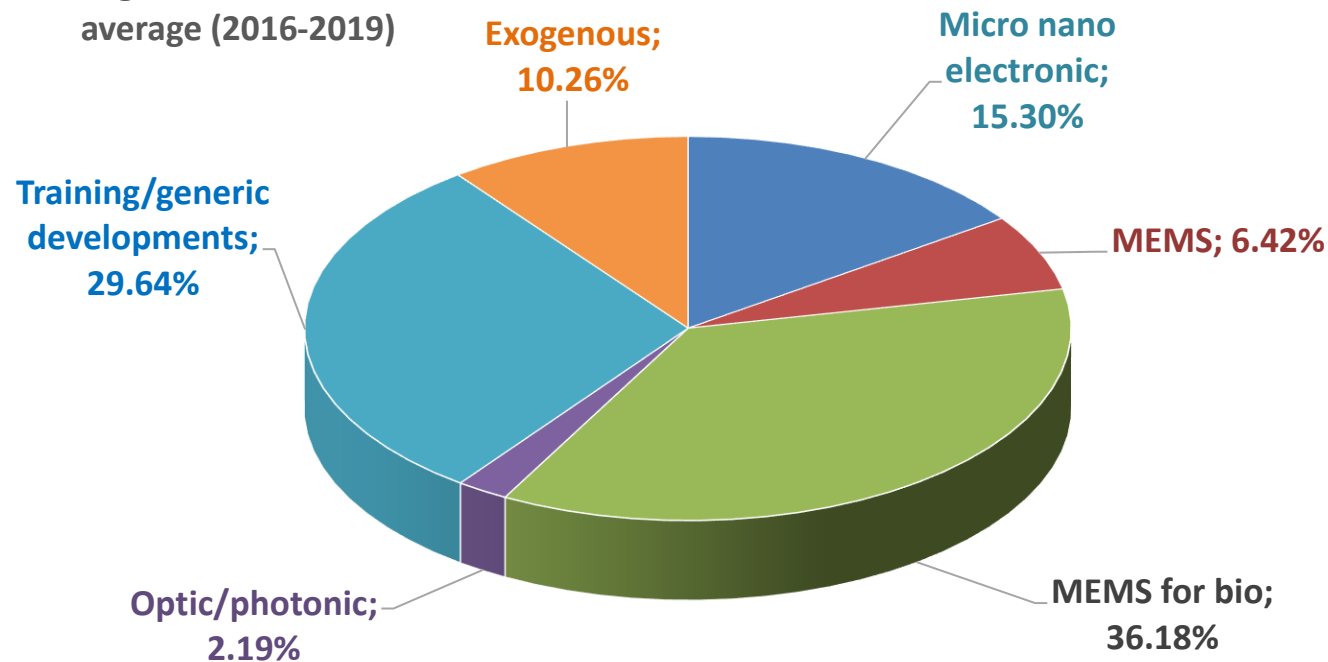
Yearly
Beam
Hours:
1463 H

• Status of technical activity

* 2 months Clean room closure for infrastructure works

Booking hours	2016	2017	2018*
Endogenous	392,5	1576	1033,5
Exogenous	5,5	108,5	124,5

Technological know how domains
average (2016-2019)

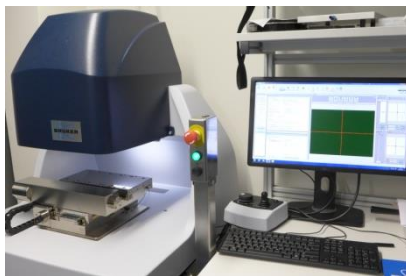
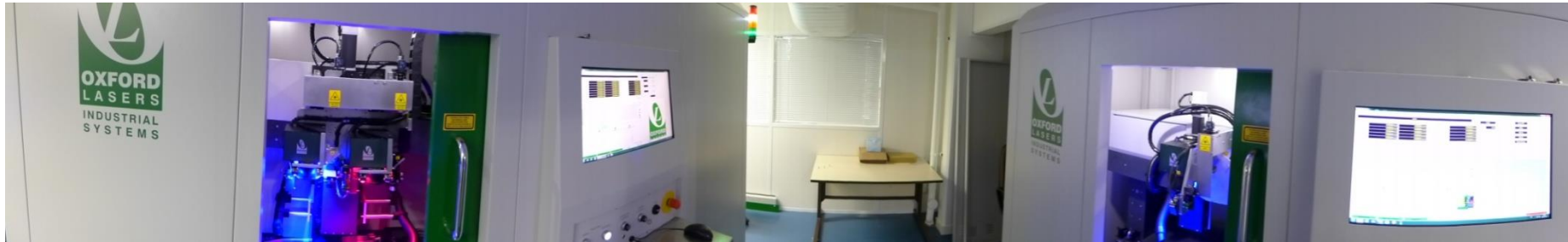


Laser processing platform for functional packaging and microsystems

- LEAF identity card
- Overview of laser processing platforms
- Project progress
 - Procurement and installation
 - Access to LEAF equipments
- Human resources
- Socio-economic impact
 - Academic partnership
 - Industrial partnership
 - Collaborative projects
- Ripple effects
- Scientific production
- Sustainability

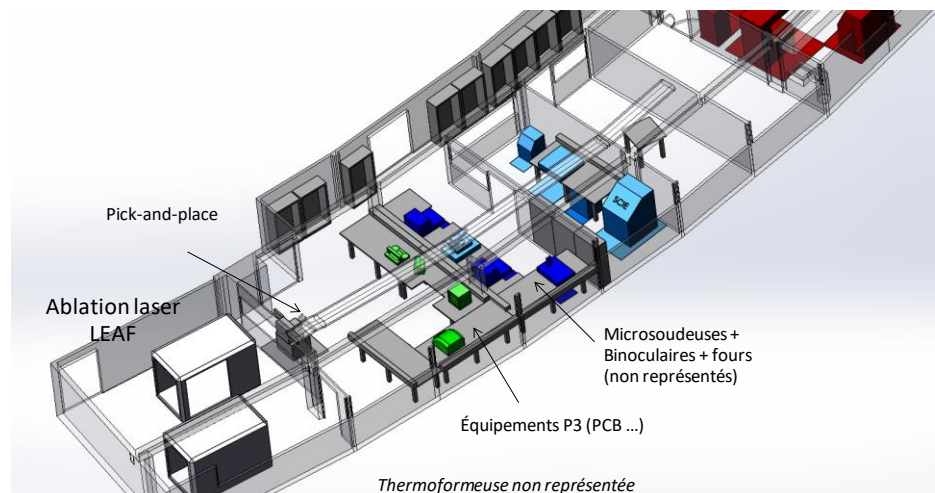
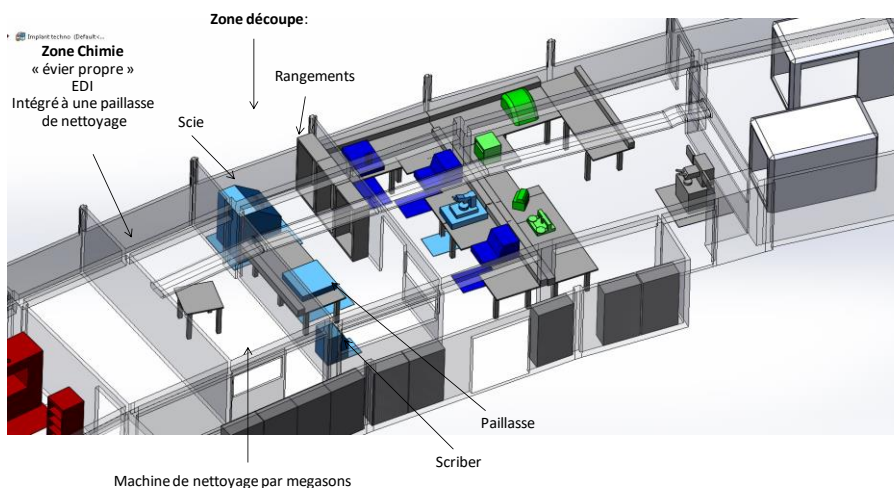
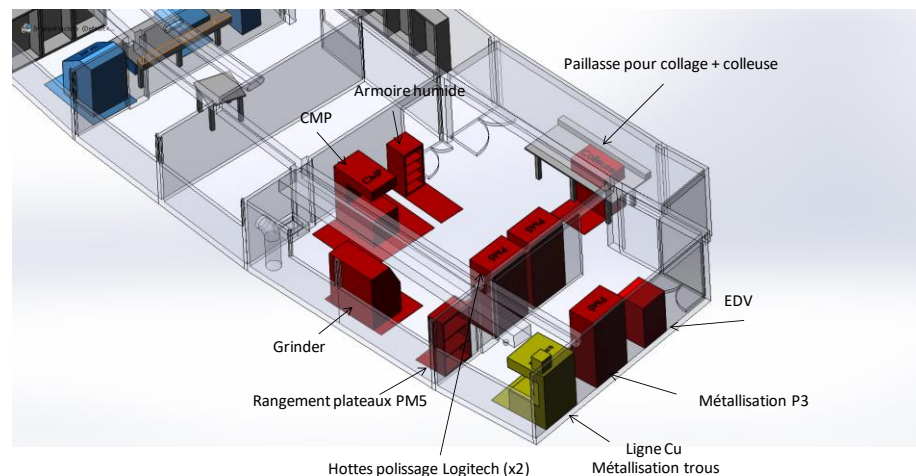
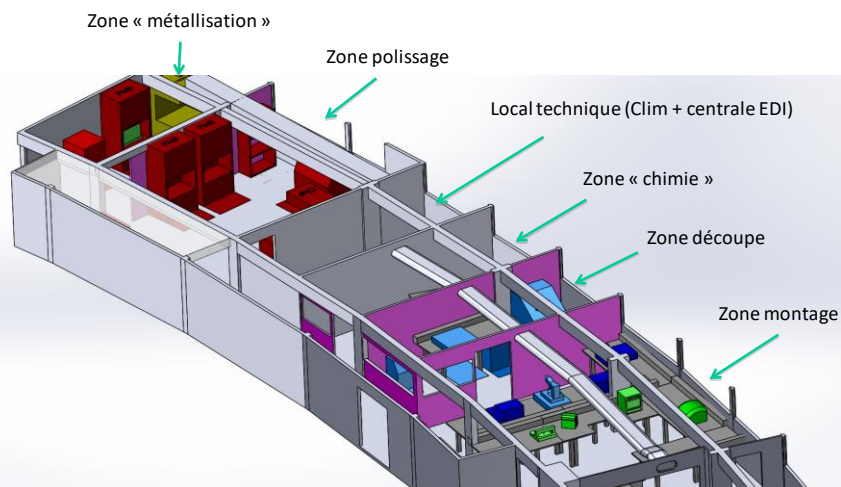


Ripple effect: packaging platform

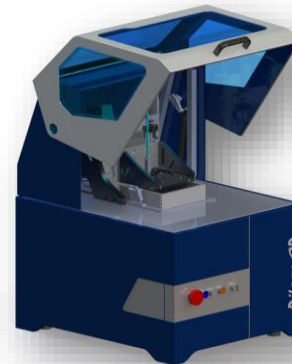
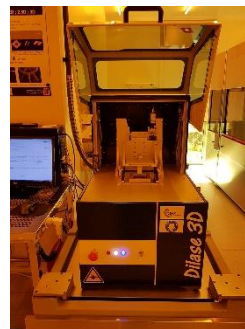


		Supplier	Year installation	Cost (k€)	Funding source
1	Equipment for laser micromachining - Femtoseconde laser source – Three wavelengths (1030-515-343 nm)	Oxford Lasers	2014	1080.000	PIA-EQPX
2	Equipment for laser micromachining - Femtoseconde laser source – High power and single UV line (351 nm)				
3	Upgrade Scanner Pulse-Synchronized Output				
4	Interferometric optical profilometer	Bruker	2014	152.355	RTB/GROUPE FEDER support EQPX
5	Grinding machine for wafer thinning	G&N	2013	78.876	RTB/CPER
6	Chemical Mechanical Polishing (CMP)	ALPSITEC	2013	180.000	RTB/CPER
7	Laser lithography	KLOE	2014	200.000	FEDER support EQPX
8	Megasonic cleaning	SPS	2014	78.920	RTB
9	Dry film laminator	Bungard	2014	8.602	RTB
10	Via/hole electroplating	Bungard	2014	17.943	RTB
11	Pick-and-place	JFP	2015	105.420	CPER
Grand Total				1951.289	

Laser (87m²) Polissage (155m²) Packaging (270m²) = 512m²

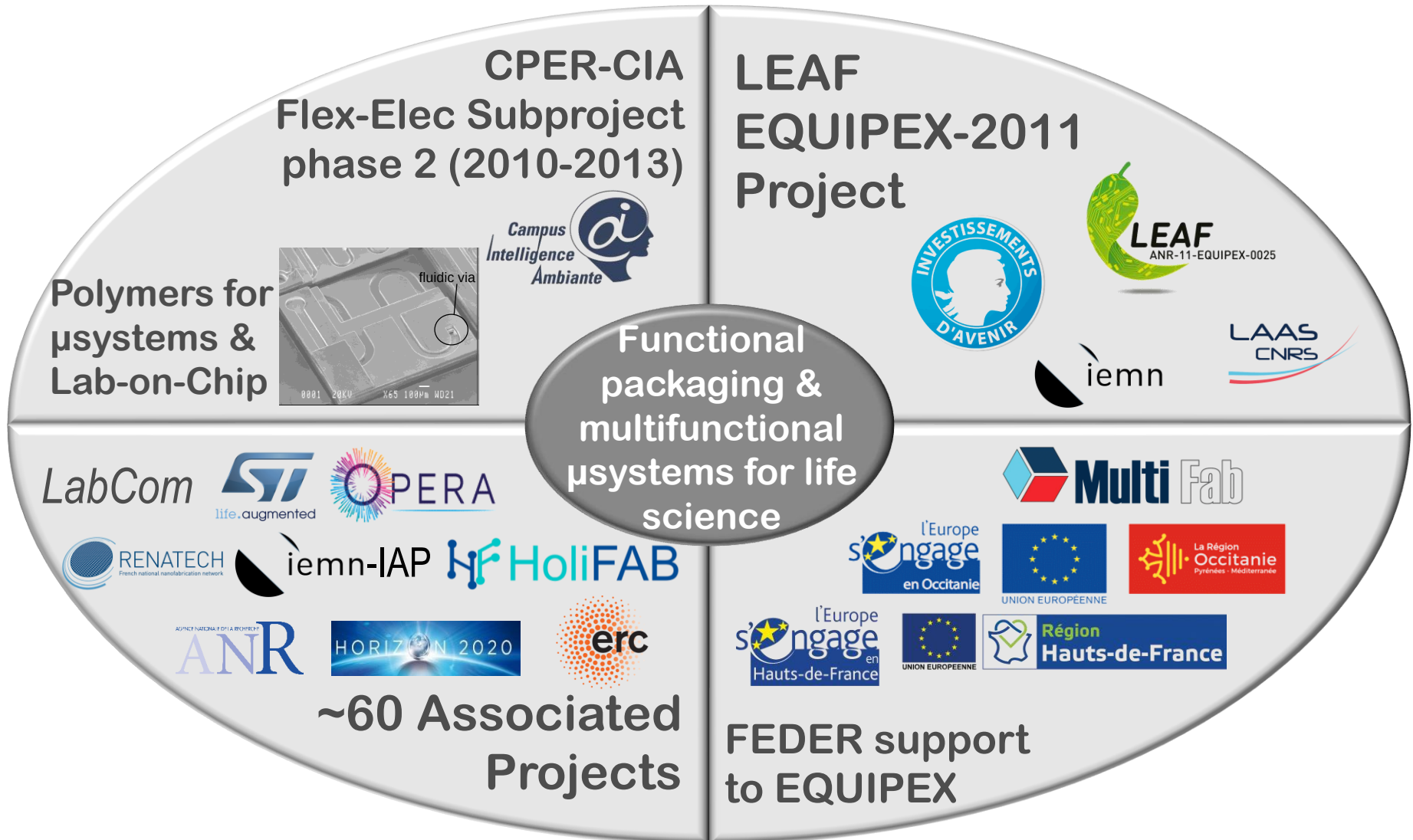


Ripple effect: 3D printing platform



		Supplier	Year installation	Cost (k€)	Funding source
1	Equipment for laser lithography - Three wavelengths (325-375-405 nm)	Kloé SA	2014 & 2015	820 000	PIA-EQPX
2	Equipment for laser stereolithography – (405 nm)				
3	Equipment for laser stereolithography – (405 nm)	Kloé SA	2018	120 000	FEDER
4	Equipment for laser stereolithography – (405 nm)	Kloé SA	2018	140 000	FEDER
5	Equipment for laser stereolithography – (405 nm)	DWS	2018	105 000	FEDER
6	Equipment for inkjet printing	CERADROP	2018	300 000	FEDER
Grand Total				1 485 000	

Ripple effects from end to end



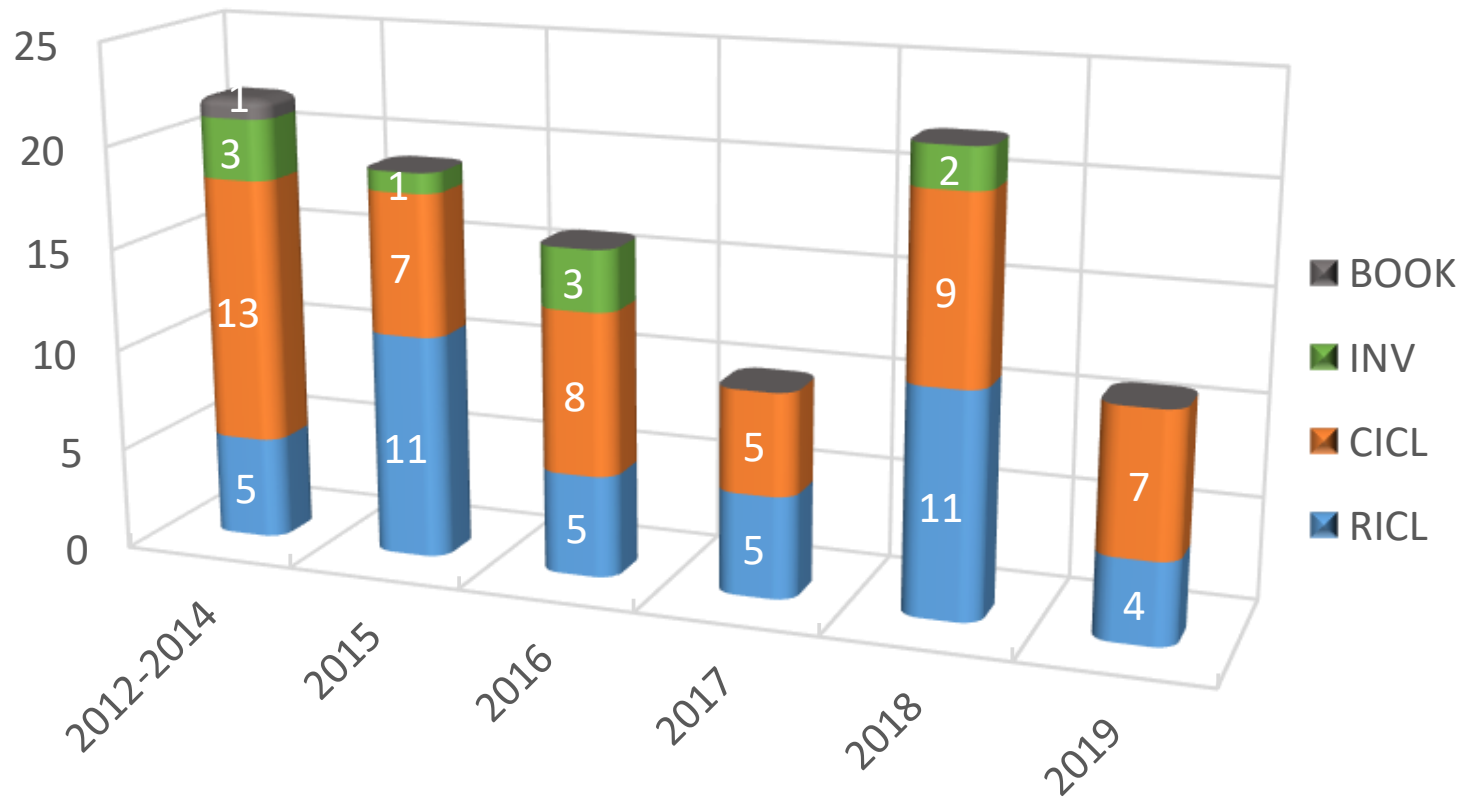
Laser processing platform for functional packaging and microsystems

- LEAF identity card
- Overview of laser processing platforms
- Project progress
 - Procurement and installation
 - Access to LEAF equipments
- Human resources
- Socio-economic impact
 - Academic partnership
 - Industrial partnership
 - Collaborative projects
- Ripple effects
- Scientific production
- Sustainability



100 Produits de Publication

- 41 RICL
- 49 CICL
- 9 INV
- 1 BOOK



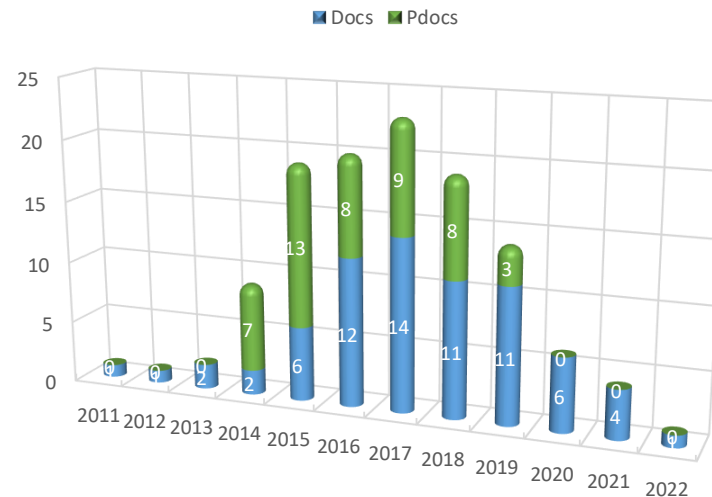
Laser processing platform for functional packaging and microsystems

- LEAF identity card
- Overview of laser processing platforms
- Project progress
 - Procurement and installation
 - Access to LEAF equipments
- Human resources
- Socio-economic impact
 - Academic partnership
 - Industrial partnership
 - Collaborative projects
- Ripple effects
- Scientific production
- Sustainability



Specification-Funding-Procurement-Operation-Use-Maintenance-Upgrading

- Operation:**
- qualified staff guaranteed in IEMN and LAAS facilities
 - LEAF is part of the national RENATECH network and are supported for that mission
 - LEAF platforms are inserted in a chain of processing tools
- Use:**
- Opening policy within the RENATECH frame work
 - Numerous research projects (~60) use LEAF platforms
 - Common Lab with STMicroelectronics and ESSILOR
- Maintenance:**
- EQPX budget available until 31 Dec 2019 – 412k€ Tranche 2
 - Billing to research groups (endogeneous) and external users (exogeneous)
- Upgrading:**
- **Critical** for keeping equipments at leading edge
 - **Critical** for surrounding equipments with ‘up-and-coming researchers = PostDocs’ and Docs with a ‘LEAF-centric’ topics.



Thank you for your attention

